NATIONAL ACADEMY OF SCIENCES

Number 2 • August 1957

IGY BULLETIN

A monthly survey by the U. S. National Committee for the International Geophysical Year. Established by and part of the National Academy of Sciences, the Committee is responsible for the U. S. International Geophysical Year program in which several hundred American scientists are participating and many public and private institutions are cooperating.

Status Report: Meteorology, Oceanography & Glaciology

The IGY programs in meteorology, oceanography, and glaciology will constitute a coordinated study of the heat and water budget of the earth.

The meteorological program is directed at the study of major atmospheric circulation patterns and mass air movements, the exchange of heat between the tropics and the poles, and the remedying of important lacuna in weather data, particularly in the Antarctic area.

Oceanographic studies seek knowledge of the great circulatory systems of the oceans, of their deep currents, and of changes in sea level. Because the oceans are the earth's great storehouse of heat and moisture, studies of the transfer of heat and water, both within the atmosphere and hydrosphere and across the air-water interface, are a primary objective of IGY meteorology and oceanography programs. Many of these studies are synoptic in nature.

Similarly, some of the main purposes of the glaciological program are to investigate the dynamic properties and mass budgets of glaciers together with the exchange of mass and energy between glaciers and their meteorological environments. Other objectives are to determine locations, areal extents, and types of glaciers, to determine the pattern of regional climatic trends and the historical pattern of climatic changes as revealed by present and past glacier activity.

Meteorology

The IGY meteorology program involves a great expansion in facilities for gathering data on weather and climate. Many new meteorological stations have been established, primarily in Arctic and Antarctic regions and along the west coast of South America. Existing facilities have been improved with the introduction of new equipment designed to increase the accuracy and scope of observations.

Special studies in radiation and atmospheric composition are also being conducted during the IGY.

A pole-to-pole chain of meteorological stations, concentrated between 70° and 80° W, is essentially complete. Their observations will produce a meridional cross-section of weather and atmosphere. Similar data is being obtained by other nations along other meridional lines. The stations in continental United States, virtually all of

which were in operation previous to IGY, have been equipped for participation in IGY meteorological programs and are now functioning in those programs. Formal training was completed and observations begun on or about July 1 at the five jointly-operated South American Stations: Puerto Montt, Quintero, and Antofagasta, Chile; Lima, Peru; and Guayaquil, Equador. All stations in Alaska, the Canadian-US Cooperative stations, and two Arctic drift ice stations are in operation.

Six USNC-IGY Antarctic stations have been fully equipped. All have been conducting standard observations, including 3-hourly surface observations; pilot balloon observations, when required for aircraft operations; continuous recording of surface temperature, humidity, pressure, precipitation, wind direction and velocity, and sunshine; and solar radiation.

A considerable amount of Antarctic weather data has already been gathered. A temperature of −100.4° F, the lowest recorded anywhere to date, was measured at the IGY Amundsen-Scott Station at the South Pole on May 11, 1957. On the same day Little America Station, only 600 miles distant, experienced 30° F. During April, May, and June of 1957, the average temperature at the South Pole was near −70° F. It is expected to be 20 to 30° lower at times during July, August, and September. Prevailing wind velocities averaged about 17 mph at South Pole Station during May, with a maximum of about 55 mph. A maximum velocity of about 78 mph was recorded on May 9 at Adare Station, and winds up to 100 mph occurred during stormy weather at Wilkes Station May 26–28.

Byrd Station reported 45.9 inches of snowfall for the period January 10 to March 31. During May, another 10.3 inches fell. Little America Station reported 22.1 inches for May.

By use of newly developed 800-gm balloons, the height of rawinsonde observations has been considerably increased. The discovery of a method of conditioning balloons by soaking them in warm diesel fuel prior to inflating has further increased their height potential. On May 13 a height of 91,000 ft was achieved at the South Pole Station. It is expected that heights of 100,000 ft or more will be reached. Antarctic stations, with the exception of Byrd, are taking observations twice daily at 0000 and 1200 GMT; Byrd Station is taking one such observation daily.

Approximately 100 other IGY stations, including about 28 operated jointly with other western hemisphere nations, are also equipped with these balloons and are following the same schedule of observations. At Quintero, Chile, the first rawinsonde observation was taken on June 4, and two-a-day soundings were begun on June 20.

At present, the IGY Antarctic Weather Central, staffed by meteorologists from three participating countries, is broadcasting the results of day-to-day synoptic weather analyses. These analyses, reaching all Antarctica and the southern hemisphere twice daily, are used for forecasting purposes. Raw data are received by Weather Central, located at Little America Station, from all of the other American Antarctic stations and from many stations operated by other countries.

Currently, the Weather Central staff prepares analyses of upper air charts at 700-, 500-, and 300-mb levels, and four sea-level charts. Thickness maps for the 1000/700 and 700/500-mb thickness, and time cross-sections for at least nine Antarctic upper air stations, are also being prepared. In addition, synoptic data accumulated and analysed at Antarctic Weather Central will ultimately help clarify the heretofore obscure influence of the Antarctic continent on the large-scale hemispheric and global circulation patterns. There is already some evidence confirming the previously expected existence of a deep cold cyclone over the central Antarctic land mass.

Time cross sections for more stations will be prepared as additional data becomes available. Pseudoadiabatic diagrams and

hodographs are prepared, as required, as well as other types of charts and diagrams.

Oceanography

The primary objectives of the IGY oceanographic program are to gain an understanding of the circulation of the ocean waters and of sea-level changes of both short and long duration and their relationship to other oceanic and atmospheric phenomena. For this work, more than 200 sea-level measuring stations, many of them newly established, and more than 70 ships are in operation or will be operated by approximately 35 participating countries.

The installation of measuring stations in the Atlantic, on selected islands and coastal promontories, is under the direction of the Lamont Geological Observatory. Stations already in operation in the Atlantic are in Barbados, Bermuda, Iceland, Fire Island, and on a Texas Tower. The Azores and Reunion stations will be in operation shortly. In the Pacific, Scripps Institution of Oceanography has installed stations on Marcus, Pitcairn, Rurutu, Canton, Johnston, Wake, and Napuka Islands. Other Pacific stations are being equipped. Of particular importance are the new stations in equatorial regions and the southern hemisphere, where observations have not been made in the past.

Besides determining variations in sea level, many of the island observatories are measuring ocean temperature and salinity to depths of 1000 ft. This will help determine to what extent changes in sea level are owing to volumetric changes, and to what extent they are caused by movements of water mass.

Van Dorn-type equipment at many stations will record waves of 5- to 15-minute duration; these waves, generally related to tsunamis, severe storms, and high-altitude atmospheric jet streams, are also believed to be present to a considerable extent at all times.

The main objectives of deep-water ship operations during IGY are to study the deep circulation of the Atlantic and Pacific Oceans and to conduct detailed, multiple-ship surveys of currents, temperatures, and chemical composition of ocean waters. Bottom topography and composition are also being studied. Most data will be accumulated over a two-year period. For practical purposes, however, such data may be considered synoptic in nature as the deeper currents are believed to be sufficiently slow-moving so that little or no change in the circulation system is likely to occur in that time.

Neutrally buoyant floats, recently developed by J. C. Swallow, of the National Institute of Oceanography of England, now make it possible to determine the depth of the more powerful, permanent ocean currents, and the depth, direction, and velocity of the deeper countercurrents.

Prior to the formal commencement of the IGY on July 1, 1957, several cruises had already been conducted in both oceans. The British research vessels *Atlantis* and *Discovery II* actually initiated the oceanographic program in March, when they met at Bermuda and then proceeded to the outer edge of the Blake Plateau, at about the latitude of Charleston, S. C., to conduct joint observations. The *Atlantis* measured deep temperature and salinity structure while the *Discovery* tracked neutrally buoyant floats at selected levels. The floats contained sound sources and tracking was done with hydrophones suspended from the bow and stern of the ship.

Shallower floats drifted to the northeast, as expected, and at expected velocities. At a depth of 2000 meters floats drifted only a few miles in four days, an amount not considered significant. At a depth of 2800 meters, however, the drift was 8 miles per day to the southwest. Thus, a level of minimum motion at about 2000 meters is indicated, with a rapidly-moving countercurrent below it.

On its way back to Plymouth, the *Discovery* achieved the most complete North

Atlantic profile to date, taking temperature, salinity, and oxygen measurements from the Grand Banks to the English Channel.

Meanwhile, in the US program, the Woods Hole research ship *Crawford* made four complete Atlantic crossings, two in the tropical North Atlantic and two over the tropical South Atlantic course profiled by the German ship *Meteor* 30 years ago. Comparison of the *Crawford* and *Meteor* profiles shows that although there were no striking changes in temperature and salinity, there has been a pronounced change in dissolved oxygen content. Especially near both ends of the profile, there is now more oxygen in the oxygen minimum layer and less in the deeper waters. Bottom water at depths below 4000 meters in the Antarctic western basin has lost as much oxygen as the deep water in the western basin of the North Atlantic. Presumably, water of sufficient density to renew the deeper waters is not at present being formed during the winters, either in the far north or the far south.

Subsidiary programs involving operation of the two drifting stations in the Arctic and measurement of CO_2 in the atmosphere and hydrosphere are also under way. Field operations begun on Fletcher's Ice Island in the spring of this year will continue for about six months. Standard oceanographic measurements, including temperature, salinity, heat flow, water depth, and other studies are being made. Similar studies will be carried out on Station A for one-month periods during the fall of 1957 and spring of 1958. Measurement of CO_2 in the atmosphere and oceans, being carried on jointly under the IGY meteorological and oceanographic programs, is designed to determine the amount of CO_2 in the atmosphere in order to establish adequate benchmarks for future trend analysis. (It has been suggested that the burning of fossil fuels may in time increase the amount of CO_2 sufficiently to affect our climate.)

Glaciology

IGY glaciological programs are now in progress to determine the volume of polar ice locked in the great ice sheets of Antarctica and Greenland and the floating ice of the Arctic basin, and to study the heat and water exchanges between these ice bodies and the atmosphere and hydrosphere. Snow stratigraphy, ice movement, temperature, and topography of the ice surface and the land beneath the ice are among the other things being studied in this program. Similar studies involve observation of the mass, budget, movement, and past and present environment of glacial ice.

Under study by United States teams are the McCall Glacier in the Brooks Range, Alaska, the Lemon Glacier near Juneau, Alaska, and the Blue Glacier in the Olympic Mountains, in Washington State. Work is also being done in the Alaska Range, Columbia Icefield, Cascade Mountains, and the Sierra Nevadas.

These glacial studies will yield knowledge on recent climatic changes and present trends in regions where meteorological records are poor or lacking.

Detailed studies will be made of the dynamics of movement, a complete accumulation-ablation cycle, and related problems in glacier morphology and chemistry. Glacier survey and census programs, involving much photogrammetric mapping, are being organized for Alaska and the continental United States.

A program for study of sea-ice physics and sea-ice-atmosphere heat exchange, under the direction of Phil E. Church, of the University of Washington, is under way on Drifting Station A in the Arctic Basin. Station A is on a large 7-foot-thick ice floe situated at about 80° N, 159° W.

The Snow, Ice, and Permafrost Research Establishment (SIPRE), of the Corps of Engineers, US Army, is undertaking a US-IGY program in Greenland. Henri Bader, of SIPRE, reports that in a 1700-foot drill

hole a temperature gradient of only 0.5° F, from 24.5° to 25.0°, per 1000 feet was measured. A second deep hole will be drilled this summer; the temperature gradient will be obtained and the rate of closing of the hole will be measured. Similar equipment is now in the Antarctic to be used to drill a deep hole in the vicinity of Byrd Station.

In the Antarctic, a 647-mile glaciology-seismology traverse from Little America to Byrd Station was completed in January 1957. The seismic profile of the traverse indicates an increase in ice thickness from about 1950 ft at the beginning of the traverse, 200 miles from Little America, to about 9850 ft, at Byrd Station. The elevation above sea level of the station is 4950 ft. Hence, the surface of the earth's crust on which the ice rests in this area is more than 4900 ft below sea level. This unexpected result reveals an interesting and hitherto unsuspected geological feature of the Antarctic continent, the significance of which is not yet known.

Deep pits have been dug at all IGY stations on the Antarctic ice cap for studies of snow stratigraphy, temperature, density and deformation, and for sampling for ice crystallography and chemical studies. The pits are ten or more meters deep. At a depth of ten meters, the annual ice-temperature amplitude is almost constant, varying no more than 0.5° C, and is within 1° of the mean annual atmospheric temperature. This provides a simple means of determining a primary climatic parameter without long-term meteorological observations.

The South Pole Station is using a snow mine for deep pit studies. The mine is now about 30 meters long and 6 meters deep. It is hoped that the mine will reach a depth of 30 meters to permit studies of structure and of the history of snow accumulation during the past several hundred years.

Snow stakes to measure movement of the ice have been set at Antarctic stations, and precipitation and ablation measurements are being recorded.

World Days During IGY

The synoptic objectives of the IGY program require that simultaneous observations be made in most of the disciplines throughout the world. Regular schedules to achieve this have been arranged. During some periods, however, an intensification in the observational programs is desirable and for this reason the World Days program was established. There are three classes of special days or periods during which special experiments or intensified observations will be undertaken: Regular World Days, World Meteorological Intervals, and Special World Intervals. (A calendar of these periods appears on the next page.)

World Meteorological Intervals (WMI) are series of ten consecutive days each in June, September, December, and March. They coincide exactly with two 'pentades' of the World Meteorological Organization and always include either a solstice or equinox, periods during which intensified meteorological observations are most desirable, at least on a predictable basis.

Regular World Days (RWD) are three or four days each month that are selected in advance. Two are consecutive days at the time of new moon; the others are at times of unusual meteor showers (Geminid, Perseid, Taurid, etc.), or near one of the lunar quarter phases. The RWD will also include the days of solar eclipse, with adjacent days for control purposes. For those types of observations which are insensitive to lunar phase or meteoric effects and for those observations which cannot be carried

(*Continued*)

INTERNATIONAL GEOPHYSICAL YEAR CALENDAR

1957–1958

JUNE 1957
(Advance Trial)

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

JULY 1957

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

AUGUST 1957

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

SEPTEMBER 1957

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

OCTOBER 1957

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

NOVEMBER 1957

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

DECEMBER 1957

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

				20	21	22
23	24	25	26	27	28	29

World Meteorological Interval

JANUARY 1958

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

FEBRUARY 1958

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	

MARCH 1958

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
2	3	4	5	6	7	1/8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

11

Regular world day

12

Day of total eclipse

APRIL 1958

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

MAY 1958

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

JUNE 1958

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

Final Calendar of Regular World Days (RWD) and World Meteorological Intervals (WMI) during the International Geophysical Year 1957-1958

Adopted by CSAGI, September 1956 and edited by CSAGI SECRETARIAT 3, AVENUE CIRCULAIRE, UCCLE-BELGIUM

10

Regular world day at new moon

JULY 1958

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

AUGUST 1958

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24/31	25	26	27	28	29	30

SEPTEMBER 1958

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

17

Regular world day with unusual meteoric activity

8

Unusual meteoric activity (but not world day)

OCTOBER 1958

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

NOVEMBER 1958

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23/30	24	25	26	27	28	29

DECEMBER 1958

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

JANUARY 1959

SUN.	MON.	TUE.	WED.	THU.	FRI.	SAT.
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

out continuously throughout the IGY period, the RWD should constitute a representative sample of the IGY period and the resulting concentration of effort should be useful in the interpretation of results in all disciplines.

Special World Intervals (SWI) are designated on a day-to-day basis by the IGY World Warning Agency in the United States, acting with the advice of forecasting centers throughout the world. A period of Alert will be declared whenever solar activity is unusually high and significant geomagnetic, auroral, ionospheric, or cosmic ray effects are probable. During the period of Alert, an SWI may be declared (at 1600 UT to commence at 0001 UT the following day) whenever the probability is high that an outstanding geomagnetic storm, with associated effects in other disciplines, will begin within a few hours. The periods of Alert and SWI will continue in effect until terminated by the World Warning Agency. An effort will be made to predict only the most outstanding disturbances in the designation of the SWI.

An example of the operation of the World Warning Agency occurred when a large solar flare, of importance 3, was reported by Krasnaya Pakhra Observatory, Moscow, USSR, as having begun at 0700 UT June 28, 1957. Although this was the only report on the flare, its importance was such that the World Warning Agency declared a state of Alert beginning at 1600 UT the same day. This was followed, on June 29, by designation of an SWI commencing at 0001 UT July 30. The SWI continued until 2359 UT July 3, and the alert ended on July 6. A very large magnetic storm began about 0400 UT June 30, lasting until about 0100 UT July 2. During the magnetic storm great auroral activity was reported, and on July 1 communications were seriously disturbed; the quality figure for a 6-hour period that day was 1, the lowest in many years.

Rockets & Satellites: Radio Tracking System

This report, one of a series on the USNC-IGY Earth Satellite Program, deals with radio tracking of the satellites. The Academy's IGY Committee assigned responsibility for the scientific radio tracking program to the Naval Research Laboratory, developer of the Minitrack system. The illustrations and much of the technical information in this discussion are extracted from reports on the subject by J. T. Mengel, who is in charge of the Minitrack Program at the Naval Research Laboratory.

Once an earth satellite has been launched, the next major task will be to find it. The small satellite will not be observable by optical means except during periods just before sunrise or just after sunset, when the satellite is illuminated by the sun against a dark background sky. Optical observation is further restricted to clear weather.

A radio transmitter carried in the satellite is expected to make the satellite observable by day or night, in poor or clear weather. Moreover, a radio receiving antenna will have a larger beamwidth, or field of view, than an optical system depending upon detection of sunlight reflected from the satellite. Therefore, the satellite will be found more easily by radio techniques.

The prime purpose of radio tracking will be to prove that the satellite is in fact orbiting and to obtain orbital data for the computation of preliminary ephemerides. Only by means of such ephemerides will the precision cameras to be used in the optical system be able to track the satellite. Moreover, radio observations of the satellite, although less precise than those by optical means, will have significant scientific value. In addition to providing information on the

precise relative distances between the tracking stations, radio observations will be more closely spaced and more frequent than the optical observations. This characteristic of the radio data will be especially valuable if the satellite is short lived; it is also expected to be important for disentangling perturbations due to gravitational anomalies.

Minitrack System

The particular system which NRL has developed is accurate enough to measure change of position as well as position. This means the satellite can be 'tracked' in addition to being found by its radio signal. And, since the transistorized satellite-borne transmitter is necessarily of minimum size and weight, the overall system has been named Minitrack. The Minitrack transmitter will normally be operated at power levels in the range of 10–80 milliwatts, depending upon the particular on-board experiments being carried. The mercury cell batteries are expected to furnish electric power for about three weeks. The transmitter uses transistors with crystal control for frequency stability.

The satellite signal is transmitted at a frequency of 108.00 megacycles. While ionospheric effects are quite large for frequencies to about 30 megacycles, these effects, although greatly reduced, are still significant at 108 megacycles; indeed, they constitute the basic limitation on the accuracy of the Minitrack system. On the other hand, these effects are not entirely detrimental. The displacement which the ionosphere imposes upon the radio image of the satellite gives a crude measure of the number of ions between the satellite and the receiving station. Ionization in the atmosphere will also affect the Doppler shift of radio signal frequency caused by motion of the satellite transmitter relative to the ground receiver. This presents another possibility for obtaining approximate data on the ionosphere.

Minitrack determines the angular position of the satellite by employing a radio phase comparison technique. Unless the satellite happens to be located in a bisector plane between a pair of receiving antennas, the radio signal from the satellite will have to travel a slightly different distance to each of these antennas. The relative phases of the received signals are dependent upon the difference in these distances and therefore upon the angular position of the satellite with respect to the plane bisecting the pair of antennas.

For example, Figure 1(a) shows two such antennas. The radio signal travels the same distance in going from the satellite to point P_1 as it does in going to antenna A_1. Therefore, the number of wavelengths is the same for both paths and the phase of the signal at point P_1 is the same as the phase of the signal at antenna A_1. The additional distance which the signal must travel to reach antenna A_2 can be measured by examining the phase of the signal at antenna A_2 relative to the phase at point P_1 (or at antenna A_1).

Since $A_1A_2P_1$ can be considered a right triangle, the angular position of the satellite from the zenith can now be calculated from the known separation of the antennas and the measured distance P_1A_2. A second pair of antennas placed with their baseline 90° to the first pair would allow calculation of a second angle. These two angles would determine completely the direction of the satellite from the antennas (see Figure 1(b)).

If the antennas are wider apart, as in Figure 1(c), the angular position can be determined with greater precision. The disadvantage of this arrangement is that uncertainties are introduced as to the number of wavelengths contained in the distance P_2A_1. The actual Minitrack antenna array consists of a combination of closely spaced and more widely separated antennas. The baseline of the closely spaced antennas is short enough that the phase difference is never ambiguous for any position of the satellite within the beam width of the system.

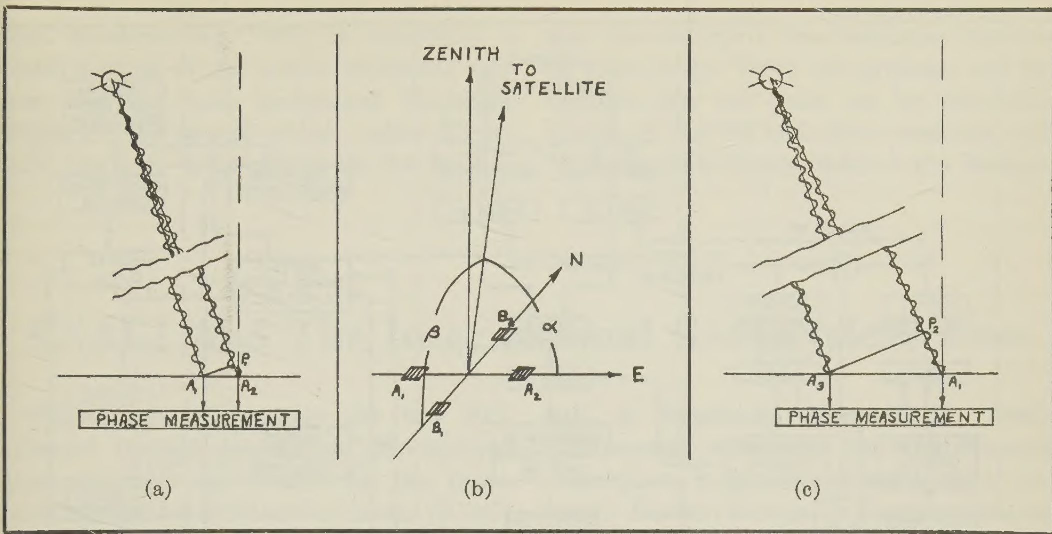

FIG. 1. *Phase Measurement in the Minitrack System.*

Minitrack Stations

The field of view, or antenna beamwidth, of the Minitrack array of receiving antennas will be 100° in a north-south direction and 10° in an east-west direction. This fan-shaped intercept pattern was especially designed for the Minitrack stations which string from north to south, approximately along a 75th meridian 'picket fence,' at the following locations: Blossom Point, Maryland; Savannah, Georgia; Havana, Cuba; Mt. Cotopaxi, near Quito, Ecuador; Lima, Peru; Antofagasta, Chile; Santiago, Chile.

Coolidge Field, Antigua Island, was chosen as the site of an eighth station, so that observational data would be available soon after launching. The ninth station is to be located at San Diego, California, for a favorable observation of the satellite on its first orbit. A tenth station, to be located at Woomera, Australia, will extend observations longitudinally. If all the equipment is operating properly, there is better than a 95% chance that the satellite will be observed by at least one of the radio tracking stations during each orbit.

The US Army is handling the communications arrangements between the radio tracking stations and the Washington computation center, which will compute and progressively refine the satellite orbit from the radio tracking data. The US Army also has responsibility for the construction of station facilities and operation of the equipment at the Savannah, Havana, and four South American sites. The Australian National Committee will perform these functions for the Woomera Station. The various other countries in which radio tracking stations are located are supporting these stations extensively through their IGY National Committees and the Inter-American Geodetic Survey. The US Air Force will operate the Antigua station, while the Naval Electronics Laboratory will man the San Diego site.

The Havana station is expected to be set up and ready for calibration by the end of September 1957. All other stations are to be ready for calibration before the middle of September. Training has been in progress since March of this year. Instructors at the prototype training station at Blossom Point are being supplied by the US Army.

Receiving Equipment

The equipment for this prototype station was built by the Naval Research Laboratory. The equipment for the remaining stations is being built commercially to the

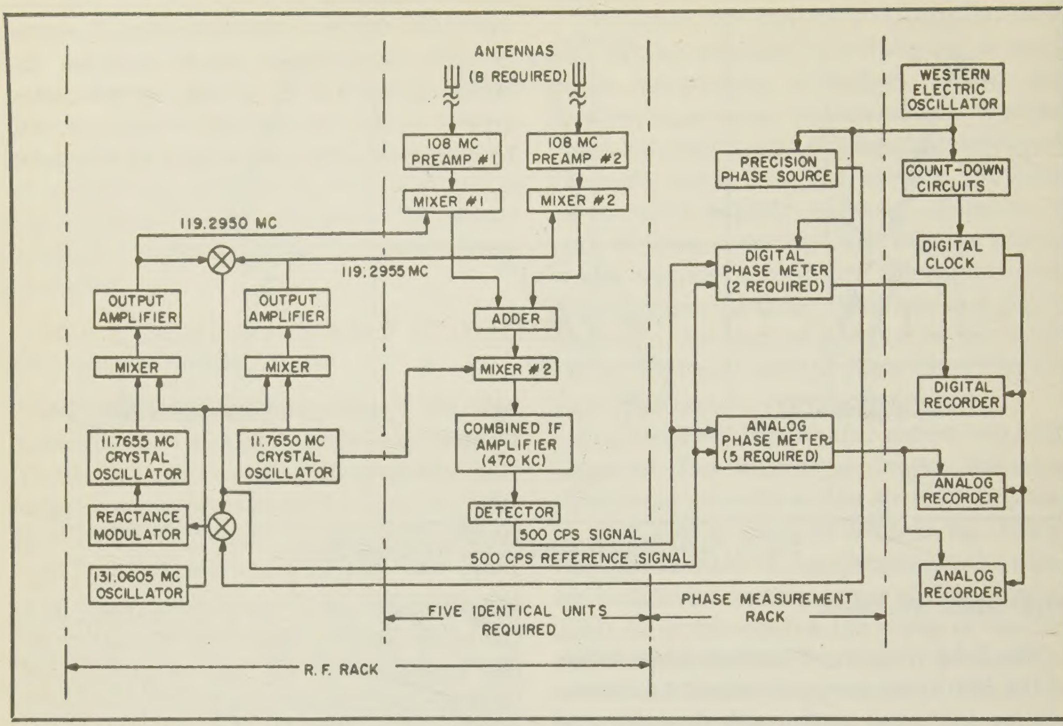

FIG. 2. *Minitrack Receiver Block Diagram.*

same design. The basic characteristics of the Minitrack receiving system are indicated by the block diagram, Figure 2.

Two very weak signals of 108 mc, but differing in phase, are received at a pair of antennas. Each of these signals is mixed (through a double superheterodyne system) with highly stable, locally generated reference signals so that the beat frequency developing from the signal of one antenna is 470 kc and that from the other is 469.5 kc. The signals at this frequency can be amplified in a common amplifier to a level of several volts without loss of precision. They are fed to a square-law detector which yields a single 500-cycle signal bearing the same phase difference relative to the internal reference as was originally present in the 108 mc signals received at the two antennas.

A system of precision electrical phase comparison circuits convert the 500-cycle signal into angular direction data of both digital and analog types. Each Minitrack station contains five phase comparison channels of this type, as follows: east-west 'fine' from the east-west 500-foot baseline; north-south 'fine,' from the north-south 500-foot baseline; east-west medium ambiguity resolution, from the east-west 64-foot baseline; north-south medium ambiguity resolution, from the north-south 64-foot baseline; north-south coarse ambiguity resolution, from the north-south 12-foot baseline.

The Minitrack signal also serves as a carrier for the telemetered data from the experiments contained in the satellite. These experiments are also dependent upon the tracking data for identification of geographical position through a common time base.

Other Radio Tracking Systems

Two less elaborate radio tracking systems have been developed for construction and operation by radio amateurs or by professional or student groups. One of these,

also developed by NRL, is essentially a simplification of the prime Minitrack system and has been designated Minitrack Mark II. The second system, called Microlock, has been developed by the Jet Propulsion Laboratory of the California Institute of Technology. These two systems, and the opportunities for their use by interested groups in the US and other countries, will be discussed in future issues of the *Bulletin.*

CSAGI And The International Geophysical Year

The Special Committee for the IGY (Comité Spécial de l'Année Géophysique Internationale) was formed by the International Council of Scientific Unions (ICSU) from representatives of members of the organizations adhering to ICSU to develop and coordinate a world program. This Committee met for the first time in October 1952. In January 1952, the Executive Committee of ICSU circularized national adhering organizations urging the formation of national committees. By January 1953, thirteen national committees had been formed; this number has increased until at the present time there are close to 60 participating countries and perhaps another dozen cooperating.

In 1953 the CSAGI established a small permanent secretariat in Brussels to assist the Special Committee in its task of coordinating the national programs. This has been accomplished principally by means of international meetings of representatives of national committees. Such meetings were held in Brussels in 1953, in Rome in 1954, in Brussels in 1955, and in Barcelona in 1956. In 1956, Adjoint Secretaries for the Antarctic, Arctic, Eastern Europe, South Africa, and the Western Hemisphere were appointed to assist in the development and coordination of the IGY program in their regions. Four Antarctic Regional Conferences have been held—the first in Paris (July 6–10, 1955), the second in Brussels (September 8–14, 1955) and the others in Paris (July 1956 and June 1957). An Arctic Conference was held in Stockholm (May 22–25, 1956). Conferences were held for the Western Hemisphere in Rio de Janeiro (July 16–21, 1956); Eastern Europe in Moscow (August 20–25, 1956); South Africa (February 11–15, 1957) and the Western Pacific in Tokyo (February 25–March 2, 1957).

The officers and members of CSAGI are listed below; members reflect representation on behalf of various ICSU unions and similar international technical organizations.

Officers and Bureau Members: Professor Sydney Chapman, President; Dr. Lloyd V. Berkner, Vice President; Dr. Marcel Nicolet, Secretary-General; Professor V. V. Beloussov; Professor J. Coulomb.

International Astronomical Union (IAU): Professor A. Danjon, Dr. Y. Öhman.

International Union of Geodesy and Geophysics (IUGG): Professor V. V. Beloussov, Professor J. Coulomb, Professor G. Laclavère, Dr. V. Laursen, Professor N. V. Pushkov, Professor P. Tardi.

International Scientific Radio Union (URSI): Dr. W. J. G. Beynon, Professor M. Boella, Father P. Lejay, Mr. A. H. Shapley.

International Union of Pure and Applied Physics (IUPAP): Dr. J. A. Simpson, Dr. S. Vallarta.

International Geographical Union (IGU): Sir James Wordie.

International Union of Biological Sciences (IUBS): Dr. A. F. Bruun.

World Meteorological Organization (WMO): Dr. T. E. W. Schumann, Professor J. Van Mieghem.

International Consultative Committee for Radio Communications (CCIR): Professor B. van der Pol, Mr. J. van der Mark.

CSAGI also designated thirteen of its members as Reporters to assist in the coordination of the national programs within each discipline as follows:

Discipline	Reporter	Union
World Days	A. H. Shapley	URSI
Meteorology	J. Van Mieghem	WMO
Geomagnetism	V. Laursen	IUGG
Aurora and Airglow	S. Chapman	ICSU
Ionosphere	W. J. G. Beynon	URSI
Solar Activity	Y. Öhman	IAU
Cosmic Rays	J. A. Simpson	IUPAP
Longitude and Latitude	A. Danjon	IAU
Glaciology	J. M. Wordie	IGU
Oceanography	G. Laclavère	IUGG
Rockets and Satellites	L. V. Berkner	ICSU
Seismology	V. V. Beloussov	IUGG
Gravity Measurements	P. Lejay	URSI

IGY Annals Announced

CSAGI has arranged for the publication of the *Annals of the International Geophysical Year* by the Pergamon Press, Ltd., London. The Annals are to constitute a central record of IGY activity and proceedings and of technical manuals.

Volume I will be an Introductory Volume to the International Geophysical Year. Volume II will comprise Reports of Proceedings of the International Geophysical Year. Volumes III-VI will consist of technical manuals in the various disciplines.

Volume III, first to be published, is an Instruction Manual For Ionospheric Studies in the International Geophysical Year. It will consist of four instruction manuals for the Ionosphere Section and will be completed in two issues of the Annals. The first issue contains Part I—"Ionospheric Vertical Soundings;" the second will contain Parts II, III, and IV, and will contain "The Measurement of Ionospheric Absorption," "The Measurement of Ionospheric Drifts," and "Miscellaneous Radio Measurements."

The publisher expects to bring out a maximum of four to six volumes of the Annals, averaging about 400 pages each, during 1957 and 1958. Subscription rates are $17 per volume. Inquiries may be directed to the Pergamon Press, Ltd., 122 East 55th Street, New York 22, N. Y., or 4 & 5, Fitzroy Square, London, W. 1.

World Data Centers

With more than 60 nations participating in the IGY, with some 10,000 scientists and observers taking measurements and observations at more than 2000 stations distributed around the earth and from pole to pole, it is apparent that vast quantities of data will be acquired. A first step in the utilization of the results of IGY is the orderly compilation of these data, their safe and proper storage in accessible centers, and their indexing. These problems have been the subject of international deliberations for some two years.

At the CSAGI meeting in Brussels in the fall of 1955, a proposal was put forward for the centralization of all IGY records and data in world centers which would assure that the data were properly stored and catalogued and that they were readily available to geophysicists for research. Several nations indicated a willingness to undertake this responsibility or to provide explicit centers for explicit disciplines. CSAGI examined these offers and a plan has now been developed whereby the United States will assume responsibility for IGY World Data Center A, the USSR will assume responsibility for Center B, and Center C will be dispersed throughout Western Europe and the Pacific.

Plans for the United States World Data Center have now been developed. A Data Coordination Office will be established in the National Academy of Sciences to direct this effort, and the Academy has selected archive centers for the respective disciplines. Each of the following institutions has accepted responsibility for the discharge of

this important aspect of the international IGY program:

Discipline	Institution
Aurora I (Visual Observations)	Cornell University
Aurora II (Instrumental Observations)	University of Alaska
Airglow, Ionospheric Physics	National Bureau of Standards (CRPL)
Cosmic Rays	University of Minnesota
Geomagnetism, Gravity, Seismology	U.S. Coast & Geodetic Survey
Glaciology	American Geographical Society
Latitude and Longitude	U.S. Naval Observatory
Meteorology	National Weather Records Center
Oceanography	Texas A. & M. College
Solar Activity	University of Colorado
Earth Satellites and Rocketry	National Academy of Sciences

Detailed plans for the organization and operation of these Centers are now being developed. International agreements have been made whereby data which reaches one Center will be exchanged with other Centers abroad thus assuring that each Center will comprise a complete repository of the IGY data.

Data Center B, to be operated by the USSR, is to be divided into two sub-centers:

Sub-center 1, Novosibirsk: meteorology, geomagnetism, longitude and latitude, glaciology, oceanography, seismology, and gravity.

Sub-center 2, Moscow: aurora and airglow, ionospheric physics, solar activity, cosmic rays.

Data Center C, to be operated by several nations in Western Europe and the Pacific, consists of the following sub-centers:

Discipline	*Country*
Geomagnetism	Denmark and Japan
Aurora	Sweden and Great Britain
Airglow	France and Japan
Ionosphere	Great Britain and Japan
Solar Activity	Switzerland, Italy, Great Britain, France, German Federal Republic, and Australia
Cosmic Rays	Sweden and Japan
Glaciology	Great Britain
Meteorology	World Meteorological Organization
Seismology	International Central Seismological Bureau (Strasburg)

The tasks of the data centers will begin very soon after July 1957 and will continue through 1959. By then most of the data will be properly stored, catalogued, and available for consultation by scientists.

USSR Rocket and Satellite Program

In the latter part of June, CSAGI received and distributed the USSR Rocket and Satellite Program for the IGY. Text of the USSR document states that preliminary proposals call for use of both rockets and satellites to study these aspects of the upper atmosphere: (1) structural parameters, (2) optical properties, (3) ultraviolet and X-ray radiation and absorption, (4) corpuscular solar radiation and aurorae, (5) cosmic rays, particularly their origin and intensity and the periods of time the particles wander in space, (6) ionospheric physics, (7) magnetic fields, (8) micrometeors and meteorites and (9) physical and chemical processes ' the upper air—through introduction chemical reagents into the atmosphere.

Rocket firings will be made along the meridional belt 50°–60°E in three zones, the Arctic (Franz Joseph Land), the middle latitudes of the USSR, and the Antarctic (mainly in the area of Mirny). Total number of firings indicated is 125: 25 in the first zone, 70 in the second, and 30 in the third. The launchings will be evenly spaced throughout the IGY, the program states, although none are scheduled for the Arctic zone until 1958. The rockets will carry instrumented "containers" to heights ranging up to 200 km.

Satellites will be launched from the USSR, the report says, at a small angle to the meridian. Thus, a nearly polar orbit will be attempted, and a successful satellite will be observable in all areas of the earth except "the central areas of the Arctic and Antarctic." No indication is given as to the number of satellites whose launching will be attempted nor are launching dates specified. However, the statement with respect to even spacing of rocket firings is also applicable to satellite launchings.

Fourth Antarctic Conference

The Fourth Antarctic Conference, Paris, June 13–15, 1957, was attended by delegates from participating committees of eleven nations: Argentina, Australia, Belgium, Chile, France, Great Britain, Japan, New Zealand, Union of South Africa, USSR, and USA.

Presided over by the CSAGI Adjoint Secretary for the Antarctic, Colonel Georges Laclavère, the Conference opened with a session devoted to scientific papers on various geophysical problems of the Antarctic. Reports on the status of various committee programs were presented. Working groups on radio communications, logistics and mutual support, the weather central, and meteorology met, reviewing the status of operations in these areas and finalizing arrangements for the IGY period.

A proposal by New Zealand, that an informal symposium be held in New Zealand during the period February–March, 1958, when Antarctic scientists wintering-over this season would be returning, was received favorably by the Conference. A similar proposal from Argentina for a symposium in the ~~spring~~ of 1959 was endorsed by the Conference. IGY groups in New Zealand and Argentina were authorized to proceed with the fuller development of their plans.

The question of an extension of Antarctic research beyond the IGY period was discussed. There was unanimous recognition of the scientific value of continued Antarctic investigations. Taking into cognizance, however, the fact that CSAGI officially terminates at the end of IGY, the Conference adopted the following recommendation:

"Considering the scientific importance of further observations in the Antarctic after the end of the IGY to best achieve the scientific investigations carried out on this occasion and to make use of the investments and observations made in the various stations.

"Recommends that the Bureau of CSAGI at its next meeting forwards to the ICSU Executive Board the recommendation expressed as follows:

"That ICSU appoints a scientific committee to examine the merits of further investigations in the Antarctic, covering the entire field of science and to make proposals to ICSU on best way to achieve such program. That in view of the desirability of avoiding an interruption in the current series of IGY investigations in Antarctica, ICSU takes immediate action in order that the finding be available by the middle of August."

Antarctic Notes

Weather at the South Pole

During the past Antarctic summer, the IGY Amundsen-Scott South Pole Station observed temperatures ranging generally between 0° and −20°F. By the end of February, the temperature had fallen rapidly to −67°, by the end of March to −87° and, on May 11, to a new world record of −100.4°F.

The record low came after two days of steadily falling temperatures. Highest read-

ing during May was −30.1°F on the 15th while the average temperature for the month was −68.2°F. (A more recent communication reports that Ronald C. Taylor, using climatological data and empirical relationships, has made a minimum temperature forecast for the Pole of −112°F, plus or minus 3°.)

A few hundred feet above the surface, the temperature increases as much as 50°F, then decreases with height to the tropopause three miles above the polar plateau where the temperature is still slightly higher than at the surface.

The temperature inside the tunnels surrounding and interconnecting the buildings at the South Pole Station lags behind the outside temperature, but at the time the record low was reached this too was already close to −70°F. Moist air from the buildings caused fog in the tunnels, reducing visibility to a matter of yards. Outside, the air was clear. The temperature of the snow on May 11 was −101.5°F. Snow in fine crystal form has been surprisingly frequent but accumulates slowly.

In addition to record low temperatures, the weather during May was characterized also by record high winds. This unique feature resulted in a very high chill factor. The average wind speed during May was 15 knots with peak gusts of 47 knots on the 25th. Upper winds over the South Pole have been variable and quite strong—as much as 130 miles per hour.

Neutron monitor studies

A neutron pile monitor designed and built under the direction of John A. Simpson, Enrico Fermi Institute for Nuclear Studies, University of Chicago, was installed on the icebreaker USS *Arneb* and operated throughout Deep Freeze I and II, 1955–56 and 1956–57, respectively. This work is part of a larger study of secondary radiation from the low-energy portion of the primary cosmic ray spectrum. Approximately 75% of the cosmic ray particles to which the neutron pile monitor is sensitive fall within a magnetic rigidity range where the geomagnetic field of the earth may be used as a particle rigidity analyser. Neutron pile monitors have been installed at various locations in differing magnetic latitudes; the monitor on the icebreaker has supplied information on the variation of cosmic ray intensity with latitude changes which can be interpreted to give the variation of the earth's geomagnetic field and the location of the geomagnetic equator in space. United States Navy Task Force 43 has been most cooperative in rescheduling the route of the *Arneb* both going to and returning from the Antarctic in order to provide crossings of the geomagnetic equator at desirable locations.

On February 23, 1956, occurred a solar flare with associated large increase in cosmic ray intensity; this was only the fifth time that such an association had been observed. The *Arneb* was in the harbor of Wellington, New Zealand, at the time and thus the neutron monitor aboard provided an extra station in the network. The significance of the Wellington observations is that Wellington is outside of the impact zone, as is Chicago, Illinois. These two widely separated stations yielded precise information on the time of onset, rate of rise, the maximum intensity, and the rate of decline of the temporary increase.

Preprinted from *Transactions, American Geophysical Union,* Vol. 38, No. 4, Aug. 1957